

Appendix L
cPAH Data and RAL Exceedance Areas
Relative to 2014 ROD RALs

1 Introduction

As part of this Pre-Design Investigation (PDI) Data Evaluation Report (DER) for the middle reach of the Lower Duwamish Waterway (LDW), remedial action level (RAL) exceedance areas were developed by comparing data in the design dataset with RALs. This process was performed as defined in the U.S. Environmental Protection Agency's (EPA's) November 2014 LDW Record of Decision (ROD) (EPA 2014) for all contaminants of concern (COCs), with the exception of carcinogenic polycyclic aromatic hydrocarbons (cPAHs). RAL exceedance areas for cPAHs in the DER are based on RALs in the LDW explanation of significant differences (ESD) (EPA 2021). EPA prepared the ESD for cPAHs to recalculate the cPAH RALs, cleanup levels, and target tissue levels to reflect the latest scientific understanding of cPAH toxicity. The ESD provides RALs requiring remedial action in the LDW for cPAHs.

This appendix evaluates the implications of using cPAH RALs from the ROD (EPA 2014) rather than cPAH RALs from the ESD (EPA 2021). Both sets of RALs are presented in Table L1-1. RALs for cPAHs are expressed as toxic equivalents (TEQs) (i.e., cPAH TEQs), which relate the toxicities of the seven cPAHs to that of benzo(a)pyrene.¹ The Lower Duwamish Waterway Group is voluntarily evaluating whether additional RAL exceedance areas (i.e., relative to those shown in Maps 3-1a to 3-1n of the DER) would be identified using cPAH RALs from the ROD (EPA 2014).

Table L1-1
cPAH RALs in the 2014 ROD and 2021 ESD

RAL Category	Depth Interval	cPAH TEQ RALs ($\mu\text{g}/\text{kg dw}$)	
		ROD (EPA 2014) Table 28	ESD (EPA 2021) Table 3
Intertidal Sediments			
Recovery Category 1	Top 10 cm (4 inches)	1,000	5,500
	Top 45 cm (1.5 feet)	900	5,900
Recovery Categories 2/3	Top 10 cm (4 inches)	1,000	5,500
	Top 45 cm (1.5 feet)	900	5,900
Subtidal Sediments			
Recovery Category 1	Top 10 cm (4 inches)	1,000	5,500
	Top 60 cm (2 feet)	1,000	5,500
Recovery Categories 2/3	Top 10 cm (4 inches)	1,000	5,500
	Top 60 cm (2 feet)	-	-
Shoaled Areas in FNC	Top to authorized navigation depth plus 2 feet	1,000	5,500

¹ The seven cPAHs included in the cPAH TEQ are benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. cPAH TEQs can also be referred to as benzo(a)pyrene equivalents, as in the ESD (EPA 2021).

Notes:

cPAH: carcinogenic polycyclic aromatic hydrocarbon

dw: dry weight

ESD: explanation of significant differences

FNC: Federal Navigation Channel

RAL: remedial action level

ROD: Record of Decision

TEQ: toxic equivalent

This appendix presents the following:

- A summary of the cPAH-only samples analyzed during the Phase II PDI
- A comparison of cPAH results in the design dataset to the 2014 ROD RALs and 2021 ESD RALs
- An evaluation of the effects of RAL selection on RAL exceedance areas
- An assessment of preliminary technology options for cPAH-only areas identified using 2014 ROD RALs
- Consideration of initial Phase III data gaps

2 Additional Phase II samples analyzed for cPAHs

In addition to chemical analyses conducted per the PDI Quality Assurance Project Plan (QAPP) for the middle reach (Windward and Anchor QEA 2022), as well as the Phase II QAPP Addenda (Anchor QEA and Windward 2024a, b), cPAHs were analyzed in eight additional samples and compared to the 2014 ROD RALs to refine the cPAH-only exceedance areas. These analyses occurred because cPAH TEQs at or near these locations in pre-PDI or PDI samples were less than the ESD RAL (EPA 2021) but greater than the 2014 ROD RALs (EPA 2014). These eight samples were from four locations: 1516, 1587, 1588, and 1589 (Maps L-1 and L-2). cPAH TEQs for all eight of these samples were less than both the ROD and ESD RALs (Table L2-1).

Table L2-1
Additional Phase II samples analyzed for cPAHs

Area	Phase II Sample				Rationale for Analysis
	Location Number	Sample ID	Interval (cm)	cPAH TEQ (µg/kg dw)	
RM 2.6W	1587	SS1587	0–10	750 J	Samples were collected to horizontally bound surface-only 2014 ROD RAL exceedances both upstream and downstream of Phase I PDI location 1189.
	1588	SS1588	0–10	200 J	
RM 2.6W	1516	SS1516	0–10	98.7 J	Samples were collected to horizontally bound surface and subsurface 2014 ROD RAL exceedance downstream of Phase I PDI location 1202.
		IT1516	0–45	560 J	
RM 2.9W	1589	IT1589B	45–75	150 J	Vertical extent information was collected at Phase I location 1264, which had a subsurface 2014 ROD RAL exceedance for cPAHs.
		IT1589C	75–105	160 J	
		IT1589E	122–152	18 J	
		IT1589G	182–212	37 J	

Notes:
 cPAH: carcinogenic polycyclic aromatic hydrocarbon
 ID: identification
 PDI: Pre-Design Investigation
 RAL: remedial action level
 RM: river mile
 ROD: Record of Decision
 TEQ: toxic equivalent

3 Comparison of cPAHs with ROD RALs and ESD RALs

This section presents a comparison of the design dataset for the middle reach with cPAH RALs from both the 2014 ROD and 2021 ESD (Table L3-1) (EPA 2014, 2021). A total of 38 samples (21 surface sediment, 15 intertidal subsurface sediment, 1 subtidal subsurface sediment, and 1 shoaling core interval) had cPAH TEQs greater than the 2014 ROD RALs. Only 8 of these 38 samples (6 surface sediment and 2 intertidal subsurface sediment samples) had cPAH TEQs exceeding the ESD RAL. Details regarding the locations with cPAH TEQs greater than the 2014 ROD RAL are shown on Map L-1 (surface sediment) and Map L-2 (subsurface sediment). Sample-specific details are provided in Attachment L-1.

**Table L3-1
 Summary of cPAH RAL Exceedances in the Design Dataset**

Interval	Comparison with 2014 cPAH ROD RALs		Comparison with cPAH ESD RALs	
	No. > RAL/Total	%	No. > RAL/Total	%
Surface (0–10 cm)	21/454	4.6	6/454	1.3
Subsurface intertidal (0–45 cm)	15/96	16	2/96	2.1
Subsurface subtidal (0–60 cm)	1/71	1.4	0/71	0
Shoal intervals (depth varies) ¹	1/81	1.2	0/81	0

Notes:

1. Shoal interval samples consisted of shoaled material in the FNC (i.e., sediment above the authorized dredge depth) and sediment from the overdredge interval.

cPAH: carcinogenic polycyclic aromatic hydrocarbon

ESD: explanation of significant differences

FNC: Federal Navigation Channel

RAL: remedial action level

ROD: Record of Decision

Of the 38 samples with cPAH ROD RAL exceedances, 26 also had exceedances for other contaminants and/or exceeded the cPAH ESD RAL (Attachment L-1). The 12 samples with cPAH TEQs above the 2014 ROD RALs and below the ESD RALs that did not have other RAL exceedances are shown on Maps L-1 and L-2.

As in the DER, after considering sample-by-sample RAL exceedances, the next step was to determine RAL exceedance areas. Map L-3 shows areas where exceedances of the 2014 ROD RALs for cPAHs result in polygons that extend beyond the RAL exceedance areas identified in the DER (Map 3-1 series); these areas, referred to as “cPAH-only areas,” are shown as orange polygons. The changes shown on Map L-3—relative to the RAL exceedance areas shown in the Map 3-1 series—include four new areas (i.e., the Federal Navigation Channel [FNC] at RM 1.6, the under-structure intertidal area at RM 2.4E, the intertidal area at RM 2.6W, and the intertidal area at RM 2.9W), as well as four areas where a cPAH polygon expands the footprint of an existing RAL exceedance area (i.e., Areas 23, 12, 9, and 8) (Table L3-3). As described in Table L3-3, no remedy is needed in the FNC area at RM 1.6, because the interval with the exceedance of the cPAH ROD RAL is buried beneath shoaled material, and thus no exposure is currently possible. In addition, should the U.S. Army Corps of Engineers (USACE) conduct maintenance dredging of this area in the FNC in the future, sediments in this location would be removed, leaving a surface with concentrations below the 2014 ROD RALs.

Table L3-3
Summary of cPAH-only Areas Identified using the 2014 ROD RAL for cPAHs

2014 ROD RAL cPAH Areas	Exceedance Type (EF relative to 2014 ROD RAL)	Area Description
cPAH-only area in the FNC at RM 1.6	Subsurface shoaling area (EF of 2.0)	Exceedance in overdredge interval is currently buried beneath shoaled material, meaning there is no potential for exposure. If USACE FNC maintenance dredging is conducted in this area in the future, this material will be removed (based on PDI data, this material would qualify for open-water disposal). Thus, no remedy is needed in this area.
Expanded portion of RAL exceedance area 23 at RM 2.3E	Surface (EF of 1.4)	Intertidal; this area may be within RAA boundary once 30% RD is complete.
cPAH-only area at RM 2.4E	Surface (EFs of 1.6 and 2.0) Subsurface (EFs of 1.0 and 3.7)	Mostly intertidal; most of this area is located under an overwater structure.
cPAH-only area at RM 2.6W	Surface (EF of 1.6)	Intertidal
Expanded portion of RAL exceedance area 12 at RM 2.6E	Subsurface (EF of 1.1)	Intertidal
Expanded portion of RAL exceedance area 8 at RM 2.7W	Surface (EF of 1.9) Subsurface (EFs of 1.0 to 1.3)	Intertidal and subtidal areas; subtidal portion of area may be within RAA boundary once 30% RD is complete.
Expanded portion of RAL exceedance area 9 at RM 2.7E	Surface (EF of 1.6)	Mostly intertidal; this area may be within RAA boundary once 30% RD is complete.
cPAH-only area at RM 2.9W	Subsurface (EF of 2.8)	Intertidal (adjacent to an overwater structure)

Notes:

cPAH: carcinogenic polycyclic aromatic hydrocarbon

EF: exceedance factor

FNC: Federal Navigation Channel

PDI: Pre-Design Investigation

RAA: remedial action area

RAL: remedial action level

RD: remedial design

RM: river mile

ROD: record of decision

RM: river mile

USACE: U.S. Army Corps of Engineers

4 Preliminary Remedial Technology Options

As described in Section 3.4.2 of the DER, the 2014 ROD (EPA 2014) presents flow charts used to identify remedial technologies that may be applicable in RAL exceedance areas. Given that the cPAH-only areas where a remedy may be performed (as identified on Map L-3 and summarized in Table L3-3) are primarily intertidal, potential preliminary remedial technology options may include monitored natural recovery, area-specific technology, enhanced natural recovery, partial dredge and cap, and dredge and backfill. Engineering considerations evaluated during 30% remedial design (RD) will be used to select remedial technologies. In addition, it is likely that some cPAH-only areas will be

within remedial action area (RAA) boundaries once 30% RD is complete. These cPAH-only areas will be addressed in an appendix to the 30% RD report.

5 Consideration of Phase III Data Gaps

This section considers possible data gaps related to the DQOs shown in Table L5-1 for the cPAH-only RAL exceedance areas. While no data gaps have been identified for the cPAH-only areas, as described in the DER, additional data gaps could be identified during 30% RD.

Table L5-1
Consideration of Data Gaps for cPAH 2014 ROD RAL Areas

DQO	Evaluation of Phase III Data Gaps
Further horizontal delineation (DQOs 9 and 10)	While cPAHs are generally bounded horizontally in areas with 2014 ROD RAL exceedances, the need for additional horizontal delineation will be considered as part of 30% RD.
Further vertical delineation (DQO 12)	No additional vertical delineation is needed in RAL exceedance areas based on cPAH exceedances relative to the 2014 ROD RALs.
Other engineering data (DQO 14)	The potential need for additional engineering data was considered for the cPAH-only areas; no data gaps have been identified. The need for additional data for these areas will be evaluated as part of 30% RD.

Notes:

cPAH: carcinogenic polycyclic aromatic hydrocarbon

DQO: data quality objective

RAL: remedial action level

RD: remedial design

ROD: Record of Decision

6 References

- Anchor QEA, Windward. 2024a. Pre-Design Investigation Quality Assurance Project Plan Addendum No. 1 for the Lower Duwamish Waterway Middle Reach - Phase II Sampling. Final. Anchor QEA and Windward Environmental LLC, Seattle, WA.
- Anchor QEA, Windward. 2024b. Quality assurance project plan addendum No. 2 for the Lower Duwamish Waterway middle reach - Phase II sampling for the Inlet at RM 2.2W. Draft. Submitted to the US Environmental Protection Agency April 19, 2024. Anchor QEA and Windward Environmental LLC, Seattle, WA.
- EPA. 2014. Record of Decision. Lower Duwamish Waterway Superfund Site. US Environmental Protection Agency.
- EPA. 2021. Proposed explanation of significant differences. September 2021. Lower Duwamish Waterway Superfund site. US Environmental Protection Agency Region 10, Seattle, WA.
- Windward, Anchor QEA. 2022. Pre-design investigation quality assurance project plan for the Lower Duwamish Waterway - Middle Reach. Final. Submitted to EPA November 21, 2022. Windward Environmental LLC and Anchor QEA, Seattle, WA.

Attachment L-1

Sample-Specific Details

Details of Samples with cPAH ROD RAL Exceedances

PDI Loc.	Location ID	RM	RAL Category	Year	cPAH TEQ (µg/kg)	2014 ROD RAL EF	ESD RAL EF ¹	Other RAL Exceedances ¹
RM 1.6 to 2.3								
1002	LDW23-SC1002	1.6	Subtidal (shoal)	2022	2,040 J	2.0	0.37D	None
-	2154-DSS-01	2.2	Surface (0–10 cm)	2012	4,200	4.2	0.76	Total PCBs, arsenic
-	2154-DSS-09	2.2	Surface (0–10 cm)	2012	2,800 J	2.8	0.51	Total PCBs, lead, mercury, zinc, PAHs, other SVOCs
-	2154-DSS-12	2.2	Surface (0–10 cm)	2012	110,000	110	20	Total PCBs, chromium, lead, zinc, PAHs, other SVOCs; also exceeds cPAH ESD RAL
-	Sea Tac Marine-2	2.2	Surface (0–10 cm)	2011	2,100	2.1	0.38	Total PCBs, dioxins/furans, PAHs
-	Sea Tac Marine-3	2.2	Surface (0–10 cm)	2011	9,200	9.2	1.7	Dioxins/furans, zinc, BBP, 2,4-dimethylphenol, PAHs; also exceeds cPAH ESD RAL
-	LDW18-DawnFoods	2.3	Surface (0–10 cm)	2018	1,400 J	1.4	0.25	Total PCBs
Under Structure at RM 2.4E								
1812	LDW23-SS1812	2.4	Surface (0–10 cm)	2023	1,980 J	2.0	0.36	None
	LDW23-IT1812	2.4	Intertidal (0–45 cm)	2023	3,320	3.7	0.56	None
1813	LDW23-SS1813	2.4	Surface (0–10 cm)	2023	1,620 J	1.6	0.29	None (exceedances for other PAHs over-ridden by toxicity testing conducted as part of Phase II sampling)
	LDW23-IT1813	2.4	Intertidal (0–45 cm)	2023	903	1.0	0.15	None
RM 2.6 to 2.8W, including Under Structure								
1189	LDW23-SS1189	2.6	Surface (0–10 cm)	2023	1,570 J	1.6	0.29	None
1202	LDW23-SS1202	2.7	Surface (0–10 cm)	2023	1,940 J	1.9	0.35	Total PCBs
	LDW23-IT1202	2.7	Intertidal (0–45 cm)	2023	1,130 J	1.3	0.19	None
1526	LDW24-SS1526	2.7	Surface (0–10 cm)	2024	9,800 J	9.8	1.8	PAHs; also exceeds cPAH ESD RAL
1527	LDW24-IT1527	2.7	Intertidal (0–45 cm)	2024	6,300 J	7.0	1.1	Also exceeds cPAH ESD RAL
1212	LDW23-SC1212	2.7	Subtidal (0–60 cm)	2023	1,030 J	1.0	0.19	Dioxins/furans
1815	LDW23-SS1815	2.7	Surface (0–10 cm)	2023	3,500 J	3.5	0.64	Total PCBs, dioxins/furans, PAHs
	LDW23-IT1815	2.7	Intertidal (0–45 cm)	2023	972	1.1	0.16	None

PDI Loc.	Location ID	RM	RAL Category	Year	cPAH TEQ (µg/kg)	2014 ROD RAL EF	ESD RAL EF ¹	Other RAL Exceedances ¹
1828	LDW24-IT1828	2.7	Intertidal (0–45 cm)	2024	2,100 J	2.3	0.36	Dioxins/furans
1829	LDW24-SS1829	2.8	Surface (0–10 cm)	2024	1,900 J	1.9	0.35	None
	LDW24-IT1829	2.8	Intertidal (0–45 cm)	2024	2,600 J	2.9	0.44	Dioxins/furans
1224	LDW23-SS1224	2.8	Surface (0–10 cm)	2023	12,600	13	2.3	Total PCBs, PAHs, other SVOCs; also exceeds cPAH ESD RAL
1561	LDW24-IT1561	2.8	Intertidal (0–45 cm)	2024	1,360 J	1.5	0.23	None
1564	LDW24-SS1564	2.8	Surface (0–10 cm)	2024	3,700 J	3.7	0.67	PAHs
RM 2.6 to 2.8E, including Beach 6 area								
1201	LDW23-IT1201	2.6	Intertidal (0–45 cm)	2023	965	1.1	0.16	None
1209	LDW23-SS1209	2.7	Surface (0–10 cm)	2023	1,760 J	1.8	0.32	Total PCBs
-	LDW18-CleanScapesB	2.7	Surface (0–10 cm)	2018	1,630	1.6	0.30	Total PCBs
1543	LDW24-IT1543	2.7	Intertidal (0–45 cm)	2024	2,800 J	3.1	0.47	Total PCBs
-	DENW6721-SS16A-2014	2.8	Surface (0–10 cm)	2014	7,200	7.2	1.3	Total PCBs, PAHs; also exceeds cPAH ESD RAL
1228	LDW23-SS1228	2.8	Surface (0–10 cm)	2023	8,300 J	8.3	1.5	Total PCBs, PAHs; also exceeds cPAH ESD RAL
1231	LDW23-SS1231	2.8	Surface (0–10 cm)	2023	1,350 J	1.4	0.25	Arsenic, zinc, fluoranthene
1233	LDW23-IT1233	2.8	Intertidal (0–45 cm)	2023	4,030	4.5	0.68	Arsenic
1551	LDW24-IT1551	2.8	Intertidal (0–45 cm)	2024	1,050 J	1.2	0.18	Arsenic
1555	LDW24-IT1555	2.8	Intertidal (0–45 cm)	2024	55,000 J	61	9.3	Total PCBs, mercury, PAHs; also exceeds cPAH ESD RAL
1556	LDW24-IT1556	2.8	Intertidal (0–45 cm)	2024	1,090 J	1.2	0.18	Arsenic
1557	LDW24-SS1557	2.8	Surface (0–10 cm)	2024	4,100 J	4.1	0.75	PAHs
RM 2.9W								
1264	LDW23-IT1264	2.9	Intertidal (0–45 cm)	2023	2,560 J	2.8	0.43	None

Notes:

- 1. Bold text** indicates EFs for samples with cPAH TEQs above the ESD RAL.
 - 2. Blue text** indicates samples for which no other chemicals had RAL exceedances.
- BBP: butyl benzyl phthalate
cPAH: carcinogenic polycyclic aromatic hydrocarbon
EF: exceedance factor

ESD: explanation of significant differences

ID: identification

PAH: polycyclic aromatic hydrocarbon

PCB: polychlorinated biphenyl

PD: Pre-Design Investigation

RAL: remedial action level

RM: river mile

ROD: Record of Decision

SVOC: semivolatle organic compounds

TEQ: toxic equivalent